THE EFFECTS OF FOREST FERTILIZATION ON WILDLIFE

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ABSTRACT

A literature review covering direct and indirect effects of fertilization to wildlife was conducted. Hazards to wildlife from operational use of urea are minimal, and fertilizer-induced changes in quality and quantity of wildlife forage are generally beneficial. Wildlife feeding damage to conifer seedlings may be increased by fertilization. Changes in wildlife carrying capacity should be examined relative to the effects of combined silvicultural treatments and over broad geographic areas.

INTRODUCTION

Forest fertilization has become an operational management practice in the Pacific Northwest during the past 10 years. That extensive research has occurred or is under way on the influence of fertilization on tree growth is evidenced by the number of studies reported at this conference. Although the primary objective of fertilization is to improve tree growth, the added nutrients are also available to other plants in the ecosystem, including those used as forage by wildlife. For a brief period at the time of fertilization, the nutrients are available, in concentrated form, to a number of wildlife species. The purpose of this paper is to review current knowledge of forest fertilization-wildlife relationships, with emphasis on the use of urea in the Pacific Northwest. Since data specific to the Pacific Northwest are limited, it will be necessary to draw on information from other forested areas of North America.

DIRECT EFFECTS OF UREA ON WILDLIFE

The direct hazard urea presents to wildlife is influenced by a variety of factors, including its toxicity, palatibility, and availability in the environment.

TOXICITY

The acute toxicity of urea, expressed as the LDLO (lowest dose, administered by any route other than inhalation, reported to cause mortality) is 3000 mg/kg for intraveneous and subcutaneous routes of exposure to dogs. An oral LDLO from 28.5 to 88.0 mg/kg has been reported for sheep (Knomann et al. 1973, Repp et al. 1955). The mechanism of urea toxicity is through its conversion, in the presence of the enzyme urease, to ammonia and carbon dixide. Urease is produced by bacteria found in the digestive system of both ruminants and simple-stomached animals (Visek 1962), as well as the soil (Conrad 1942).

In ruminants, large intakes of urea result in the liberation of amounts of ammonia in excess of that which can be metabolized (Repp et al 1955). Excess concentrations of ammonia cause a rapid pH change, which results in mortality of rumen microbes, inability of the liver to detoxify the excess ammonia entering the blood, and elevated concentrations of ammonia in peripheral blood. Although the exact mode of ammonia toxicity is unclear, Visek (1968) believed it resulted from interference with normal metabolic processes at intracellular sites.

The importance of rate of intake to toxicity of urea is shown by its history of use as a N supplement to ruminant feeds at concentrations of up to 3% of the diet. Urea is converted to ammonia and then to microbial protein and amino acids by rumen microbes. Microbial protein is subsequently made available through its digestion in the abomasum and small intestine of the ruminant. In this way urea serves as an inexpensive source of protein for animal production (Hale 1956).

Toxicity of urea in ruminants is also influenced by the overall composition of the diet since high levels of readily fermentable carbohydrates facilitate microbial synthesis of protein from ammonia in the rumen (Church 1969). A greater tolerance to urea toxicity has also been observed in ruminants fed diets high in nature protein (Church 1969, Kromann et al 1973).

PALATABILITY

To assess the potential hazard of urea fertilization to forest wildlife in the Pacific Northwest, Postovit conducted a series of field and laboratory experiments with mammals (Postovit 1976a) and birds (Postovit 1976b). In these experiments the deer mouse *Peromyscus maniculatus* was chosen as a representative mammal and the Japanese quail *Coturnix coturnix* was selected to represent gallinaceous birds (i.e., grouse and pheasants). In Postovit's laboratory tests, acceptance of urea in the pellet form used in forest fertilization was extremely low in mammals, with consumption by only one of 38 mice tested. Urea was not accepted as food under normal conditions in the field.

In quail, acceptance of urea was also low, and was related to the amount contained in the experimental diets. Toxic effects were not observed in either birds or mammals fed diets in which urea pellets could be discriminated against during normal feeding. When urea was presented to mice in a water solution in which it could not be selected against, symptoms of intoxication were observed at the higher urea concentrations tested. Symptoms disappeared within one day upon feeding of normal water and roughage, while animals kept on urea solutions died.

The molarity of urea water causing toxicity (0.75 M and 1.0 M) is considered higher than levels that would occur in the field as a result of a fertilization program. Milled urea which could not be discriminated against was fed to quail in increasing dietary concentrations with a resulting decrease in food intake. No symptoms or toxicity were observed, although production and hatchability of eggs declined for some treatments. Weight losses occurred, but were reversible and survival of chicks produced was unaffected.

AVAILABILITY IN THE ENVIRONMENT

The availability of urea in the forest environment is a major factor in determining its potential hazard to wildlife. Postovit (1976a) examined dissipation rates of urea over a range of field conditions and found they were related to application rate, vegetation density, soil moisture, and precipitation patterns.

Under conditions in which forest fertilization is normally done; i.e., 168 kg N/ha applied to closed canopy conifer plantations, high ambient air humidity and soil moisture, and frequent rain, Postivit found that solid urea would remain available as a food source for a period of 18–36 hr.

Given the extremely low palatability of urea, the fact that several day's feeding is required to produce toxic symptoms and the reversibility of these symptoms once they occur, and urea's rapid rate of dissipation due to its solubility under field conditions, Postovit (1976a, 1976b) concluded that forest fertilization with urea is not likely to adversely affect mice or gallinaceous birds. The greatest potential hazard is with fertilizer spills at heliports or transfer facilities, where larger quantities of urea pellets, or high concentrations in standing water can occur. These situations are easily avoided with careful handling and prompt cleanup of spilled fertilizer.

INDIRECT EFFECTS OF FERTILIZATION ON WILDLIFE

In contrast to direct effects, fertilization-induced changes in vegetation are much more likely to indirectly affect wildlife. Fertilizer applications to rangeland are widely used to increase both the quantity and nutritive value of forage for livestock. Behrend (1973) reviewed the state of knowledge With regard to wildlife management forest fertilization relations and point out that our understanding is "mostly crude speculation." Changes in nutritive quality, quantity, palatability, and botanical composition of vegetative cover, and increased rates of vegetative succession resulting from fertilization all have little-studied implications for forest wildlife.

NUTRITIVE QUALITY OF FORAGE

Williams (1969) reviewed the literature on the effects of fertilization on forage quality. Generally, improvement in some parameters of nutritive quality resulted from fertilization.

Segelquist and Rogers (1975) observed a significant increase in crude protein content, but not in dry matter digestibility, with N fertilization of *Lonicera japonica*, an important deer food in the southeastern United States. Similarly, King and McKee (1978) noted increases in crude protein in several forage types they fertilized, but changes in dry matter digestibility were inconsistent. Stanek et al. (1979) measured increases in N content (% dry weight) of *Gautheria shallon* and *Pteridium aquilinum* in fertilized stands of *Pseudotsuga menziesii* on Vancouver Island, B.C. In northern California, Oh et al. (1970) recorded significant increases in crude protein of tissue of *Pseudotsuga menziesii* seedlings which lasted for 3 yr following fertilization with 112 kg N/ha.

FORAGE PRODUCTION

Increased quantities of deer forage following fertilization have been reported for a number of plant species. However, in the Pacific Northwest, Stanek et al. (1979) reported a decrease in biomass of *Gautheria shallon* and *Pteridium aquilinum* after fertilization of *Pseudotsuga menziesii* stands. They concluded that this decrease was the result of increased overstory shading as a result of the tree crowns responding to fertilization. Thinning alone or thinning plus fertilization allowed more light to reach the understory and biomass of these understory species increased relative to untreated stands.

Wolters and Schmidtling (1975) observed a reduction in total numbers of browse plants in fertilized *Pinus palustris*, *P. elliottii* and *P. taeda* plantations in Mississippi but recorded a substantial increase in numbers of desirable browse plants. They reported that overall habitat quality for deer was improved by the greater accessibility afforded by the reduction in understory. Thus botanical composition of the understory community may change in response to fertilization.

Fertilization may also modify seed production in browse plants. In the southeastern United States, fruit production on *Lonicera japonica* was significantly reduced from 15 to 6 kg/ha following application of 175 kg N/ha. Numbers of acorns produced by fertilized *Quercus ilicifolia* in New Jersey were reduced from numbers produced by unfertilized trees but weight of acorns produced was 50% greater due to increased size of individual acorns.

FORAGE SELECTION

Palatibility of plants often improves following fertilization. Increased use of plants may be a desirable wildlife management goal but may interfere with the forester's goal if tree growth or seed production is affected. Anderson et al. (1974) observed from two to fourfold increases in deer use of *Quercus undulata* stands following fertilization. Even greater increases, as indicated by both pellet group deposition on fertilized plots and use of *Pseudotsuga menziesii* shoots, were recorded by Oh et al. (1970).

The incidence of squirrel feeding on *Pinus elliottii* cones was significantly higher on fertilized than unfertilized trees (Asher 1963). Gessel and Orians (1967) recorded substantially higher levels of rodent feeding on terminal buds of *Abies amabilis* saplings following fertilization and tentatively attributed this increase to the 20% increase observed in N content of trees. Sharply increased levels of wildlife injury to *Pseudotsuga menziesii* seedlings treated with urea at 224 kg N/ha were observed in western Washington (USFS 1969); feeding by black-tailed deer, snowshoe hare and blue grouse all increased similarly. Radwan et al. (1974) examined the rate of deer browsing of nursery grown seedlings fertilized with different N sources (ammonium sulfate, calcium nitrate, urea) and detected no differences attributable to N source.

CARRYING CAPACITY INFLUENCES: RESEARCH NEEDS

The studies reviewed above provide examples of the types of responses, both of vegetation and wildlife, which occur as a result of forest fertilization. Each response is important in itself but in isolation does not allow prediction of the effect of fertilization on carrying capacity of the managed forest for wildlife. Lawrence (1969) presented a hypothetical view of the positive influence of fertilization, and other silvicultural treatments, on carrying capacity of managed *Pseudotsuga menziesii* forests for black-tailed deer. Research to test these hypotheses remains to be carried out.

Fertilization is only one of the management of practices currently being applied to North American forests. To obtain a realistic idea of future conditions for wildlife (and the species or species groups must be specified) in managed forests, it will be necessary to examine individual silvicultural activities in the context of the entire system. Thus the matrix of managed stands in relation to each other through time must be considered, in light of the requirements of the wildlife species of interest.

Timing of treatments relative to stand age and stocking level, and nature of the associated vegetative community will result in varied effects on carrying capacity. Initially it is logical to examine the effects of individual treatments, in some degree of isolation. The ultimate response of the wildlife species or community of interest must be determined for broader geographical areas. Management objective, which may range from increased diversity of nongame species to maximization of harvest of hunted wildlife.

SUMMARY

Direct hazards of forest fertilization to wildlife appear to be low due to the low toxicity and palatability of urea, the necessity for prolonged feeding to cause toxicity, the wide dispersion of fertilizer over heavily vegetated areas and the rapid dissipation of solid material. Concentrations of fertilizer present a potential hazard and operational practices should be designed to (1) minimize spills and (2) immediately clean up spills when they occur. Indirect effects of fertilization include increases in quality and quantity of forage plants.

Improved palatability of vegetation has been demonstrated and may be viewed as being positive or negative from the forester's point of view, depending on whether or not feeding on crop trees is involved. Fertilization may cause changes in botanical composition and increase the rate of vegetative succession. Fertilization interacts with other management treatments to influence vegetation, and its effects on wildlife must be viewed in light of these interactions and over broad geographic areas.

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